

CITY OF ALBANY

Standard Specifications Technical Provisions

Section 17

Concrete Construction

17-1 Portland Cement Concrete Materials

17-1.1 General Requirements

17-1.1.1 General — Concrete shall consist of portland cement, concrete aggregates, water, and admixture when approved for use, in accordance with these provisions. Concrete will be specified by class or by compressive strength. When specified by class, the concrete will be designated by a symbol consisting of a number, a letter and a number. The first number is the weight of cement in pounds per cubic yard, the letter is the combined aggregate gradation and the last number is the minimum compressive strength of 28 days. The concrete class used shall be in accordance with Subsection 17-1.1.2, unless otherwise specified. Concrete specified by compressive strength shall be designed by the Contractor in accordance with Subsection 17-1.1.3.

Approved admixtures shall be in accordance with Subsection 17-1.2.4. Additional cement is permitted to obtain high early strength in concrete, except that total cement shall not exceed 700 pounds of cement per cubic yard (420 kg/m³) unless otherwise approved by the Engineer. Type III cement (High Early Strength) may be used in lieu of Type II cement in the same batch quantities as specified or approved for Type II cement.

Where Type V cement is specified, a combination of Type II cement with a minimum of 25 percent by weight Class F fly ash may be substituted provided the other provisions of Subsection 17-1.2.5 are satisfied.

17-1.1.2 Concrete Specified by Class — The concrete class and maximum slump for the various types of construction shall be as designated in the following table. The exact proportions of aggregates and water to be used in the concrete will be determined by the Engineer from test of the material to be used.

Concrete Class Use Table

Construction	Concrete	Maximum Slump	
	Class	Inches	mm
Street Surface Improvements			
Concrete Pavement (not integral with curb)	520-A-2500	3	75
Curb, Integral Curb and Pavement, Gutter, Walk, Alley Aprons	520-C-2500	4	100
Extruded Curb, Curb & Gutter	520-C-2500	2	50
	520-D-2500	2	50
Sewer and Storm Drainage Facilities			
Pipe Collars, Beam Support for Pipe, Pre-Cast Manhole Components, Catch Basins, Sidewalk Culverts	560-C-3250 ²	5	125
Sidehill Surface Drainage Facilities	500-C-2500	3	75
Pipe Bedding and Encasement, ¹			
Anchors and Thrust Blocks,			
Wall support for Pipe	420-C-2000 ²	4	100
Tunnel Backfill	480-C-2000	5	125
Trench Backfill Slurry	100-E-100	5	125
Reinforced Structures			
Bridges, Buildings, Retaining Walls	560-C-3250 ²	4	100
Cast-In-Place Piles	560-C-3250 ²	4	100
Channels and Boxes			
Invert	560-B-3250	4	100
Walls and deck	560-C-3250	5	125
Miscellaneous			
Street Light and Traffic Signal			
Foundations, Survey Monuments	560-C-3250	4	100
Fence and Guardrail			
Post Foundations	500-C-2500	5	125
Concrete not Otherwise Specified	560-C-3250	5	125
Air Placed Concrete, Method B	600-E-3250	4	100

1. Use limited to bedding concrete over which backfill will be placed not less than 40 hours after placement. For backfill after 24 hours, add 3 pints (1.4L) of calcium chloride. For backfill after 16 hours and removal of sheeting after 18 hours, use 660-C-3750 with 3 pints (1.4L) calcium chloride solution.

2. Use B Aggregate gradation when placing conditions permit.

17-1.1.3 Concrete Specified by Compressive Strength — When so specified, the Contractor shall determine the mix proportions of concrete specified on the Plans by its 28-day compressive strength within the minimum cement, maximum size coarse aggregate, and admixtures limitations designed herein or in the Specifications. The concrete shall contain not less than 560 pounds of cement or cement and fly ash per cubic yard (330 kg/m³) for concrete strengths of 3250 psi (22 MPa) or greater.

Calcium chloride may be used only with the approval of the Engineer. Admixtures proposed for use shall be evaluated in accordance with Subsection 17-1.2.4.

The proposed mix design shall be evaluated from field tests of a trial batch conforming to the size of load, materials, proportions, slump, mixing and placing equipment and procedures to be used in the actual work. The trial batch procedure herein may be waived when test data of prior performance of the proposed mix design is presented by the Contractor and approved by the Engineer. The Contractor may utilize any strength data on file with the Agency for this purpose.

When approved by the Engineer, trial batches may be placed in the Work at designated locations where concrete of a lower quality is specified. Concrete so placed will be considered for purpose of payment to be of the type of concrete specified at that location.

Test cylinders, when required by the Engineer, shall be molded from the trial batch containing the maximum water content indicated by the mix design. Fifty percent of the cylinders shall be tested at 7 days in order to establish 7-day average compressive strength information. The remaining cylinders shall be tested at no more than 28 days after molding and the average compressive strength of the five cylinders shall be at least 600 psi (4MPa) greater than the specified strength. The minimum strength of any one cylinder shall not be less than the specified strength.

The placing of concrete specified by compressive strength shall not begin until the mix design has qualified in accordance with the aforesaid test criteria. Should the source of materials or establish procedures change, new trial batches may be required.

17-1.1.4 Test for Portland Cement Concrete — Portland cement concrete shall be sampled and tested, when required by the Engineer, in accordance with the following ASTM and California Tests:

1) Sampling Fresh Concrete	C 172
2) Obtaining Drilled Cores	C 42
3) Molding and Curing Specimens	C 31
4) Compressive Strength	C 39
5) Flexural Strength	C 78
6) Slump	C 143
7) Air Content	C 173 or C 231
8) Unit Weight Yield	C 138
9) Setting of Mortar	C 191 or C 266
10) Mortar Cube Test	Calif. Test 515
11) Drying Shrinkage (with admixture)	Calif. Test 530

A compressive strength test shall consist of the average strength of two cylinders fabricated from a single load of concrete except that, if any cylinder should show evidence of improper handling, molding, or testing, said cylinder shall be discarded and the strength test shall consist of the strength of the remaining cylinder.

The frequency of sampling will be determined by the Engineer. The Contractor shall afford the engineer all reasonable access, without charge, for the procurement of samples of fresh concrete at time of placement.

Concrete specified by class under Subsection 17-1.1.2 shall attain the minimum 28-day strength designated.

Concrete specified by compressive strength under Subsection 17-1.1.3 shall attain the following 28-day strength: the average of any three consecutive strength tests shall be equal to or greater than the specified 28-day strength. Not more than 10 percent of the tests shall be less than specified 28-day strength. No test shall be less than 85 percent of the specified 28-day strength.

17-1.2 Materials

17-1.2.1 Portland Cement — All cement to be used or furnished shall be Type II low alkali portland cement conforming to ASTM C 150, or Type IP (MS) portland-pozzolan cement conforming to ASTM C 595, unless otherwise specified. Either cement shall conform to the low alkali requirements of Table IA of ASTM C 150. Type IP (MS) cement shall contain no more than 20 percent pozzolan, which shall be inter-ground with the clinker.

The Contractor shall furnish a Certificate of Compliance signed by the manufacturer identifying the cement and stating that the cement complies with

these requirements. Supporting test data shall be furnished when required by the Engineer.

Whenever suitable facilities approved by the Engineer are available for handling and weighing bulk cement, such facilities shall be used. Otherwise, the cement shall be delivered in original unopened sacks that have been filled by the manufacturer. They shall be plainly marked with the manufacturer's name or brand, cement type and weight.

Cement shall be stored in such a manner as to permit ready access for the purpose of inspection and sampling, and suitably protected against contamination or moisture. Should any cement delivered show evidence of contamination or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

All portland cement used in concrete for any individual structure shall be of the same brand and type unless otherwise approved by the Engineer.

17-1.2.2 Aggregates — Aggregates shall conform to the requirements prescribed in Section 8 and shall be approved by the Engineer prior to use. Aggregate shall be of such character that it will be possible to produce workable concrete within the limits of slump and water content in Subsections 17-1.1.2 and 17-1.3.3.

Methods of handling materials resulting in segregation, degradation or the combining of materials which results in failure to meet specifications shall not be permitted. The free moisture content of sand shall not exceed 8 percent at the time of batching.

Aggregates shall be nonreactive when tested in accordance with ASTM C 289 and evaluated in accordance with Appendix A-1 of ASTM C 33. Aggregates found to be potentially reactive may be used only upon written approval of the Engineer.

17-1.2.3 Water — Water used for concrete shall not contain deleterious substances. Water shall not contain an amount of impurities that will cause a change in the time of setting of portland cement of more than 25 percent nor a reduction in relative mortar strength at 7 and 28 days of more than 10 percent compared to results obtained with distilled water.

In conventionally reinforced concrete work, water shall not contain more than 1,000 ppm (mg/L) of chlorides calculated as Cl, nor more than 1,000 ppm (mg/L) of sulfates calculated as SO₄.

In prestressed concrete work, water shall not contain more than 650 ppm

(mg/L) of chlorides calculated as Cl, nor more than 800 ppm (mg/L) of sulfates calculated as SO₄.

In nonreinforced concrete work, water shall not contain more than 2,000 ppm (mg/L) of chlorides calculated as Cl, nor more than 1,500 ppm (mg/L) of sulfates calculated as SO₄.

17-1.2.4 Admixtures

- a) General Requirements. Admixtures shall be used as specified or approved by the Engineer. The admixture shall be measured into each batch or load in liquid form by a mechanical dispensing device and method approved by the Engineer. The quantity dispensed shall not vary more than 5 percent from the quantity specified. If more than one admixture is used, each shall be dispensed by separate equipment in liquid form. Calcium chloride shall not be used in prestressed concrete. Admixtures containing chloride ions in excess of 1 percent by weight of admixtures shall not be used in prestressed concrete. Calcium chloride may be used in reinforced concrete only upon approval of the Engineer. Admixtures to be used in grouting ducts in prestressed units shall not contain chloride ions in excess of 0.25 percent by weight of admixture.

Samples of the admixture proposed for use shall be submitted by the Contractor to the Engineer sufficiently in advance of their intended use to determine compliance with specified requirements. Approval to use an admixture shall not relieve the Contractor of the designated concrete strength requirements.

- b) Air-entraining Admixtures. Air-entraining admixtures shall conform to ASTM C 260. Tests by an approved laboratory shall provide sufficient data to determine the time-strength characteristics of the concrete mix with the admixture.

When the air-entraining agent consists of a vinsol resin-water solution that has been neutralized with caustic soda (sodium hydroxide), the Contractor may use such air-entraining admixtures without presentation of test data. In lieu of test data, the Contractor shall furnish a certificate signed by the manufacturer attesting to this fact and stating the ratio of sodium hydroxide to vinsol resin, the percentage of solids based on the residue dried at 105°C, and that no other additive or chemical agent is present in this solution.

The concentration of dilution of the admixture shall be such that it is dispensed into each batch of concrete at a rate of not less than ½ fluid ounce per 100 lbs. (0.33mL/kg) of cement.

Adjustments shall be made in the weights of the aggregates used per batch to compensate for changes in yield due to air-entrainment.

If the Contractor elects to use an air-entraining admixture, the Engineer may require that additional cement be added to the concrete mixture when the air content exceeds 4 percent. In no case shall air content exceed 6 percent.

The air content shall not deviate from the percentage specified or permitted by more than 2½ percentage points.

- c) Water Reducing, Set Retarding and Accelerating Admixtures — Water reducing, set retarding, and accelerating admixtures other than calcium chloride shall conform to ASTM C 494, and shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer. The permitted dosage of the admixture shall not exceed that which will result in an increase in the drying shrinkage of the concrete in excess of 20 percent when used in precast and pre-stressed concrete, or 10 percent when used in any other structural concrete. The strength of concrete containing the admixture in the amount proposed shall, at the age of 48 hours and longer, be not less than that of similar concrete without the admixture. The admixture shall not adversely affect the specified air content, unless permitted by the Engineer.
- d) Calcium Chloride — When calcium chloride is permitted or required to accelerate setting time and to reduce the time necessary for the concrete to reach its specified strength, it may be processed from either a brine solution or flake. If prepared from flake it shall conform to ASTM D 98. The calcium chloride solution shall contain not less than 32 percent of anhydrous calcium chloride and the hydrogen ion concentration (pH) shall be not more than 10.4 nor less than 6.0. Calcium chloride solution shall be used at the rate of not more than 3 pints per 100 pounds (30mL/kg) of cement.

17-1.2.5 Fly Ash

- a) General — Class C or Class F fly ash may be used as a substitute for part of the required Type II portland cement in a concrete mix when approved by the Engineer. The amount of Type II portland cement replaced shall be based upon trial batches in accordance with Subsection 17-1.1.3. At least an equal weight of fly ash is required as a substitute for the replaced portland cement. The maximum amount of portland cement replaced shall not exceed 30 percent by weight. Fly ash shall not be used with Type IP (MS) or Type III portland cement.

The Contractor shall furnish a Certificate of Compliance signed by the supplier identifying the type of fly ash and stating that the fly ash complies with ASTM C 618 and these Specifications. Supporting test data shall be furnished when requested by the Engineer. All testing and sampling procedures shall conform with ASTM C 311.

Separate silo storage facilities shall be provided. Suitable facilities shall be provided to discharge the fly ash into the cement hopper in accordance with Subsection 17-1.3.1. Fly ash shall be stored in such a manner as to permit ready access for the purpose of inspection and sampling and be suitably protected against contamination or moisture. Should any fly ash show evidence of contamination or moisture or be otherwise unsuitable, the Engineer may reject it and require that it be removed from the site.

All fly ash used in concrete for any individual project shall be from the same source and of the same class, unless otherwise approved by the Engineer.

- b) Class F Fly Ash — Class F fly ash shall conform to ASTM C 618 and the following specifications:

Loss on ignition	4% maximum
SO ₃ content	3% maximum
Moisture content	1% maximum
R-Factor* (only required where Type V cement is specified)	0.75 maximum

$$*R = \frac{(\% \text{ CaO-5})}{\% \text{ Fe}_2\text{O}_3} \quad \text{from fly ash oxide analysis}$$

- c) Class C Fly Ash — Class C fly ash shall conform to ASTM C 618 and the following specifications:

Loss of ignition	2% maximum
SO ₃ content	4% maximum
Moisture content	1% maximum

17-1.3 Proportioning

17-1.3.1 General — Aggregates and cement shall be proportioned by weight except that when the amount of concrete required for any one contract is 10 cubic yards (8m³) or less, the materials may be measured by volume. Materials that are proportioned by volume shall be measured in containers of known capacity.

Weight hoppers shall be charged from bins located directly over them or from conveyor belts. When conveyor belts are used, there shall be a separate belt for each size aggregate. There shall be a moisture meter installed, accurate within 1 percent of the actual moisture content, to indicate the moisture in the sand.

Bulk cement shall be weighed in an individual hopper and shall be kept separate from the aggregates until the ingredients are released for discharge. The cement hopper shall be attached to a separate scale for individual weighing.

The amount of water to be added to the mixture shall be measured into the mixing drum through a valve with a positive cutoff. When water is measured by weight, it shall be weighed on a separate scale.

Whenever a portable batch plant is set up at a new location, the scale assemblies shall be inspected and certified regardless of the date the scales were last tested.

Scales utilized in proportioning shall be either springless dial, multiple beam type, or solid-state digital strain gage transducer type. Scale graduations shall be no greater than the following:

Aggregate Scales	25 lbs.	(10 kg)
Cement Scales	5 lbs.	(2 kg)
Water Scales	5 lbs.	(2 kg)

If a multiple beam type scale is used, the scale shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will operate during the addition of the last 400 lbs. (180kg) of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.

Weighing equipment shall be insulated against vibration and movement of other operating equipment in the plant. When the entire plant is running, the scale reading at cutoff shall not vary from the weight designated by more than 1 percent for cement, 1 percent for water, 1½ percent for any size of aggregate, nor 1 percent for the total aggregate in any batch.

17-1.3.2 Combined Aggregate Gradings — The combined aggregates shall conform to the gradings specified in the following table:

Combined Gradings for Portland Cement Concrete Percentage Passing Sieves					
Sieve Size	Grading A	Grading B	Grading C	Grading D	Grading E
2" (50mm)	100	100			
1½" (38mm)	95-100	95-100	100		
1" (25mm)	64-80	80-96	95-100		
¾" (19mm)	55-71	64-80	77-93	100	100
⅝" (10mm)	37-53	40-52	50-70	92-100	90-100
No. 4	32-42	35-45	39-51	42-60	60-80
No. 8	25-35	28-38	31-41	33-47	50-70
No. 16	18-28	21-31	22-32	22-38	33-53
No. 30	10-18	10-20	12-22	17-25	19-35
No. 50	3-9	3-9	3-9	6-12	5-15
No. 100	0-3	0-3	0-3	1-5	2-6
No. 200	0-2	0-2	0-2	0-2	0-2

17-1.3.3 Concrete Consistency — The amount of water added at the mixer shall be regulated to take into account the free water in the aggregates. Free water is defined as the total water minus the water absorbed by the aggregate in a saturated surface-dry condition.

The amount of water used in the mixture shall not exceed the amount necessary to permit practical placement and consolidation of the concrete. Total free water in the mixture shall not exceed an amount producing the maximum slump specified in Subsection 17-1.1.2, and shall not exceed amounts shown in the following table:

Maximum Free Water					
Aggregate Grading	POUNDS PER CUBIC YARD (Kg/m ³) of concrete Slump in inches (mm)				
	1(25)	2(50)	3(75)	4(100)	5(125)
A	270(160)	280(166)	290(172)	300(178)	310(184)
B	275(163)	285(169)	295(175)	305(181)	315(187)
C	290(172)	300(178)	310(184)	320(190)	330(196)
D	320(190)	335(199)	350(208)	365(216)	375(222)
E	335(199)	350(208)	365(216)	380(225)	395(234)

When adverse or difficult conditions affect the placement of concrete, the

Engineer may authorize a greater slump to be used, provided the cement is increased. Water shall be added at a ratio not to exceed 32 percent of added cement per cubic yard of concrete, and such additional water and cement shall be at the Contractor's expense.

17-1.4 Mixing

17-1.4.1 General — Machine mixing will be required in all cases other than those in which it would obviously prove to be impractical, in which event hand mixing will be permitted. Mixing shall be commenced as soon as possible after the cement is placed in contact with the aggregates, but in no event shall the intervening period exceed 30 minutes.

All concrete mixers shall be of such design and construction and so operated as to provide a thoroughly and properly mixed concrete in which the ingredients are uniformly distributed. Mixers shall be maintained in proper and serviceable working condition and any part or portion thereof that is out of order, or becomes worn to such extent as to detrimentally affect the quality of mixing, shall be promptly repaired or replaced. Mixers shall not have any aluminum parts which will have direct contact with concrete.

17-1.4.2 Paving and Stationary Mixers — Paving and stationary mixers shall be equipped with an accurate automatic timing device so designed and constructed as to lock the discharge lever before aggregate and cement enter the drum, and release such lever only after the specified mixing time has elapsed. The regulation of the setting of said device shall be under the supervision of the Engineer. Water control equipment shall also be provided with each concrete mixer.

The proper proportions of aggregate, cement, and water for each batch of concrete shall be placed in the mixer, and shall be mixed for a period of not less than 1 minute after all such materials are in the drum. The minimum mixing time per batch for reinforced concrete, however, shall not be less than 1½ minutes.

The rotating speed at which the mixer shall be operated shall conform to that recommended by the manufacturer.

The total volume of materials mixed in any one batch shall exceed neither the water level capacity of the mixer nor the manufacturer's guaranteed capacity of the mixer.

17-1.4.3 Transit Mixers — The type, capacity, and manner of operation of the mixing and transporting equipment for ready-mix concrete shall conform to the current "*Standards for Operation of Truck Mixers and Agitators of the*

National Ready-Mixed Concrete Association” and the “Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau.” Transit mix concrete trucks shall be equipped with an automatic device for recording the number of revolutions of the drum during the mixing period. Each mixer and agitator shall have attached thereto in a prominent place, a metal plate or plates, installed by the manufacturer on which is plainly marked the capacity of the drum in terms of the volume of mixed concrete and the speed of rotation for the agitating and mixing speeds of the mixing drum or blades.

Each mixer shall have an identification number painted on the truck in such a location that it can be easily read from the batching platform.

The total volume of materials introduced into the mixer shall not exceed the manufacturer’s guaranteed mixing capacity. If the concrete so mixed does not meet the uniformity requirements of this subsection, the amount of materials charged into the mixer shall be reduced.

The drum of the mixer shall be completely emptied of any previously mixed load. The proper proportions of aggregate, cement, and water for each load of concrete shall be placed in the mixer and shall be mixed therein for not less than 70 nor more than 100 revolutions of the drum or blades at the speed designated by the manufacturer of the equipment as mixing speed. Additional revolutions of the drum shall be at the speed designated by the manufacturer of the equipment as agitating speed. The revolving of the drum shall be continuous until the concrete is completely emptied from the drum.

When concrete is being placed for pavement or concrete structures, all wash water shall be emptied from the mixer before any portion of the succeeding load is placed therein. For all other work, the mixer shall be empty or may carry 10 gallons of water in the drum. Adequate control of ready-mixed concrete will normally require that additional water be added and mixed into the batch at the point of discharge. Water so added shall be mixed into the load for a minimum of 30 revolutions at the rated mixing speed. Water shall not be added to the load during transit.

The total elapsed time between the addition of water at the batch plant and discharging the completed mix shall not exceed 90 minutes. Under conditions contributing to quick setting, the total elapsed time permitted may be reduced by the Engineer.

The Engineer shall be provided with a legible certified weighmaster certificate. When mix proportions have been designated for a project and are identified by number, the Engineer may accept a legible certified weighmaster certificate which shall contain the following information:

- 1) Name of Vendor
- 2) Name of Contractor
- 3) Project Location
- 4) Number of cubic yards in the load
- 5) Mix designation number
- 6) Amount of water added at the plant (including water in aggregates)
- 7) Maximum allowable water
- 8) Time and date of batching

When the mix proportions are not designated by number, or when required by the Engineer, the certificate shall contain the following additional information:

- 1) Actual weights of cement and of each size of aggregate
- 2) Brand and type of cement
- 3) Brand, type, and amount of admixture

Space shall be provided on the certificate so that amount of water added on the job may be indicated.

17-1.4.4 Hand Mixing — Hand mixing will be permitted when the amount of concrete required for any one job is one cubic yard (0.8m³) or less. Hand mixed concrete shall be mixed on a watertight platform or in a mortar box in batches not to exceed 1/3 cubic yards (0.3m³) each. The aggregates shall first be spread in a uniform layer over which the required quantity of cement shall be evenly distributed. The entire batch shall be turned with shovels until the ingredients are thoroughly blended before adding the water. After adding the proper amount of water, the batch shall again be turned with shovels until a uniform consistency is obtained. Methods of hand mixing which allow the loss of mixing water will not be permitted.

17-1.5 Transporting Batched Materials and Mixed Concrete — The compartments of trucks or other equipment used for the purpose of transporting proportioned dry aggregate and cement, or mixed concrete, shall be suitably constructed to adequately protect and prevent loss or leakage of the contents during charging, transit or discharging.

17-2 Steel Reinforcement for Concrete

17-2.1 General — Bar, wire and wire mesh reinforcement shall conform accurately to the dimensions and details indicated on the plans or otherwise prescribed. Before being placed in any concrete work, it shall be cleaned thoroughly of all rust, mill scale, mortar, oil, dirt, or coating of any character which would be likely to destroy, reduce, or impair its proper bonding with the concrete.

17-2.2 Reinforcing Steel — unless otherwise specified, reinforcing steel shall be either Grade 40 or grade 60 billet steel conforming to ASTM A 615.

Steel bending processes shall conform to the requirements of the *Manual of Standard Practice of the Concrete Reinforcing Steel Institute*.

Bending or straightening shall be accomplished so that the steel will not be damaged. Kinked bars shall not be used.

17-2.3 Wire Reinforcement — Wire reinforcement shall in all respects fulfill requirement prescribed in ASTM A 82.

17-2.4 Wire Mesh Reinforcement — Mesh reinforcement shall conform to ASTM A 185. The gage of the wire and the dimensions of the mesh shall be as shown on the Plans or in the Specifications. The wire mesh reinforcement shall be so constructed as to retain its original shape and form during the necessary handling. The effective cross-sectional area of the wire shall be equal to that specified or indicated on the Plans.

17-2.5 Samples for Testing

17-2.5.1 General — No reinforcing steel will be accepted until it has been approved by the Engineer. When required by the Engineer, samples shall be taken from bars selected by the Engineer and cut in the Engineer's presence. The Contractor shall furnish a certified mill test report for each heat or size of steel when required by the Engineer.

17-2.5.2 Reinforcing Steel Bars — When required by the Engineer, two sample bars, each 3 feet (0.9m) long and cut from different bars, shall be taken from each bar size delivered to the job site on a cumulative tonnage basis in accordance with the following schedule:

Bar Sizes (Number)	Cumulative Weight of Steel per Bar Size Delivered to Job Site	
	Tons	kg
2	1/2	(450)
3	1	(900)
4	2	(1800)
5	3	(2700)
6	4	(3600)
7	5	(4500)
8	7	(6300)
9	9	(8100)
10	11	(10000)
11	13	(12000)
14	20	(18000)
18	35	(32000)

Note: At least two sample bars shall be taken from each bar size.

17-2.5.3 Wire Reinforcement — When required by the Engineer, one sample consisting of two pieces, each 3 feet (0.9m) long, shall be taken from each 2-ton (1800kg) lot or less of each size of wire delivered to the job site.

17-2.5.4 Wire Mesh Reinforcement — When required by the Engineer, two samples of a size suitable for testing shall be taken from each 3,000 square feet (280m²) of fabric or fraction thereof.

17-3 Expansion Joint Filler and Joint Sealants

17-3.1 General — This section specifies joint fillers and sealants to be used for treating joints in portland cement concrete.

All joints which are to be sealed shall be formed with filler. The filler shall be placed in correct position before concrete is placed against it. Holes or joints in the filler shall be filled with mastic to prevent the passage of mortar or concrete from one side of the joint to the other.

17-3.2 Premolded Joint Filler — Premolded joint filler material shall consist of premolded strips of a durable resilient material.

Unless otherwise specified, premolded joint filler shall be one of the following types:

Preformed Expansion Joint Filler (Bituminous Type)
ASTM D 994

Nonextruding and Resilient Filler (Bituminous Type)
ASTM D 1751

Nonextruding and Resilient Filler (Non-bituminous Type)
ASTM D 1752

17-4 Concrete Curing Compound

17-4.1 General — Curing compound shall consist of a liquid which, when applied to fresh concrete by means of a spray gun, will form an impervious membrane over the exposed surfaces of the concrete.

The membrane may be either asphaltic or paraffin derivatives to which other waterproofing materials may have been added. Concrete curing compounds shall be designated by type as follows:

Type 1—Clear or translucent with red fugitive dye.

Type 2—White pigmented.

Type 3—Light gray pigmented.

Type 4—Black pigmented.

All compounds shall be furnished by the Contractor and shall be delivered ready-mixed in sealed original containers bearing the manufacturer's name and product identification. At the time of use, pigmented curing compounds shall be thoroughly mixed, with the pigment uniformly dispersed throughout the mixture.

The rate of application shall be such that the compound forms a continuous, unbroken film when applied to the work. The Engineer will determine the permissible rate of coverage of a curing compound.

Unless otherwise specified, Type 1 curing compound shall be used.

17-4.2 Test Requirements — Curing compounds shall be tested in accordance with ASTM C 309.

17-5 Cement Mortar

17-5.1 General — Cement mortar shall consist of a mixture of portland cement, sand and water. Cement and sand shall first be combined in the proper proportions, and then thoroughly mixed with the required amount of water.

Cement mortar shall be designated by class and proportioned by loose volume as follows:

Mortar Designation Class	Proportions	
	Parts Cement	Parts Sand
A	1	1
B	1	1½
C	1	2
D	1	2½
E	1	3
F	1	3½

The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended.

Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Retempering of mortar will not be permitted.

17-5.2 Cement — Cement shall conform to the requirements of Subsection 17-1.2.1.

17-5.3 Sand — Sand shall conform to the requirements of Subsection 17-1.5.3. In proportioning the sand, it shall be measured loose (without shaking or compacting) in measuring boxes or other suitable containers of known capacity.

17-5.4 Water — Water shall conform to the requirements of Subsection 17-1.2.3.

17-5.5 Admixtures — No admixture shall be used in mortar unless otherwise specified or approved by the Engineer.

17-5.6 Quick Setting Grout — Quick setting grout shall be a high strength, non-staining grout approved by the Engineer prior to use. It shall reach an initial set within 90 minutes at 70°F (21°C) and shall reach minimum compressive strength of 2,500 psi (17mPa) within 24 hours. Shrinkage shall be less than 0.1 percent when tested, using the test procedures of ASTM C 596. The grout shall be mixed, handled, and placed in accordance with the manufacturer's instructions.

17-6 Concrete Structures

17-6.1 General — Concrete bridges, culverts, catch basins, retaining walls, abutments, piers, footings, foundations and similar structures shall be constructed in conformity with the Plans and Specifications. Concrete for use in work

constructed under this section shall conform to the requirements of Subsection 17-1.

Safe and suitable ladders shall be provided to permit access to all portions of the work.

The compressive strength of the concrete referred to in this section will be based on the results of concrete test cylinders made and tested by the Engineer. The cylinders shall be cured under conditions similar to those affecting the structure.

When plastic-lined concrete structures are required by the Plans, the plastic liner materials shall comply with Subsection 17-2 and the installation of the liner shall be in accordance with Subsection 311-1 of the Standard Specifications for Public Works Construction.

17-6.2 Subgrade for Concrete Structures — Earth subgrade upon which concrete is placed shall be firm and free from water. Groundwater shall be kept below subgrade until the concrete has set. When the subgrade is in dry earth, it shall be thoroughly dampened with water to ensure that no moisture will be absorbed from the fresh concrete.

When the design details for the project provide for the construction of filter or drain material consisting of gravel (or combination of gravel and sand), which material will be subgrade for concrete, the placing of steel reinforcement and placement of concrete shall follow the installation of the filter or drain material as closely as practical. The filter or drain material shall be kept dewatered to the extent necessary to prevent any portion of concrete materials being deposited in water. No payment will be made for dewatering other than that which may be included in the prices bid for various items of work or when an item for dewatering is provided.

When the concrete is to be deposited on rock, the rock shall be fully uncovered, cleaned, and its surface shall be removed to a depth sufficient to expose sound rock. Bedrock shall be roughly leveled off or cut to approximately horizontal and vertical steps. Seams in the rock shall be grouted under pressure or otherwise treated as the Engineer may direct. Grouting seams in rock or otherwise treating them will be paid for as provided in the Specifications.

17-6.3 Forms — forms shall be of suitable material and of a type, size, shape, quality, and strength to ensure construction as designed. The forms shall be true to line and grade, mortar-tight, and sufficiently rigid to resist deflection during placing of the concrete. The responsibility for their adequacy shall rest with the Contractor. All dirt, chips, sawdust, nails, and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and

holes that would deface the finished surfaces. Forms previously used shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being reused. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent which will leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete.

Forms for all surfaces that will not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber, or material which will provide a surface at least equal to surfaced lumber or plywood. Any lumber or material which becomes badly checked or warped, prior to placing concrete, shall not be used.

Forms for all exposed surfaces of bridges, viaducts, over-crossings and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall be of the grade "Exterior B-B (concrete form)," conforming to the latest Product Standard for Soft Plywood, Construction and Industrial, of the national Bureau of Standards. Plywood shall be furnished and placed in 48-inch (1.2m) widths and in uniform lengths of not less than 96 inches (2.4m), except where the dimension of the member formed is less than the specified panel dimension. Plywood shall be placed with the grain of the outer plies in the direction of the span. Where plywood is attached directly to the studs or joists, the panels shall be not less than $\frac{5}{8}$ -inch (16mm) thick, and the studs or joists shall be spaced not more than 12-inches (300mm), center to center. Plywood less than $\frac{5}{8}$ -inch (16mm) thick, otherwise conforming to the requirements specified herein, may be used with a continuous backing of $\frac{3}{4}$ -inch (19mm) sheeting. All form panels shall be placed in a neat, symmetrical pattern with the horizontal joints level and continuous. All joints shall be filled with an approved quick-setting compound and finished flush with the interior of the form.

Wooden forms for copings and curbs shall have a thickness of not less than $1\frac{5}{8}$ inches (41mm) and a width of not less than the full depth of coping or curb.

Unless otherwise shown on the Plans, all sharp edges shall be chamfered with $\frac{3}{4}$ -inch by $\frac{3}{4}$ -inch (19mm by 19mm) triangular fillets. Forms for curved surfaces shall be so constructed and placed that the finished surface will not deviated from the arc of the curve.

Forms shall be so constructed that portions, where finishing is required, may be removed without disturbing portions of forms to remain in place.

Joists and stringers supporting slabs and overhangs shall be considered as falsework and designed in accordance with Subsection 303-1.6 of the Standard Specification for Public Works Construction.

Forms for girders and slabs shall be cambered as may be required by the Engineer.

Forms shall, as far as practicable, be so constructed that the form marks will conform to the general lines of the structure.

Form clamps or bolts, approved by the engineer, shall be used to fasten forms. The use of twisted-wire loop ties to hold forms in position will not be permitted, nor shall wooden spreaders be used unless authorized by the Engineer. Clamps or bolts shall be of sufficient strength and number to prevent spreading of the forms. They shall be of such type that they can be entirely removed or cut back 1 inch (25mm) inside the finished surface of the concrete. All forms for outside surfaces shall be constructed with stiff wales at right angles to the studs, and all form clamps or bolts shall extend through and fasten such wales.

Forms for cast-in-place concrete drain conduit or sewer structures will not be required for concrete to be placed directly against the sides of the excavation or sheeting, provided the following conditions are met:

- 1) If concrete is placed directly against the faces of the excavation, the faces must be firm, compact, able to stand without sloughing, and must be outside the concrete lines shown on the Plans at all points. The entire faces of excavation, against which concrete is to be placed without the use of outside forms, shall be gunited to sufficient thickness to prevent raveling of the exposed earth faces during the placing of reinforcing steel, forms and concrete.
- 2) If concrete is placed against sheeting, such sheeting shall be closely fitted and all points shall be outside the concrete lines shown on the Plans. Those surfaces against which the concrete is to be placed shall be faced with building paper. except as otherwise specified herein, all sheeting shall be removed, but not until at least 7 days after placing concrete, or until the concrete has attained strength in compression of 2,000 pounds per square inch (14 MPa).

Care shall be used in removing sheeting so as to avoid damaging the concrete. Voids left by the removal of sheeting, piles or similar sheeting components shall be backfilled with material having a sand equivalent of not less than 30 and consolidated by jetting as approved by the Engineer. When field conditions or the type of sheeting or methods of construction used by the Contractor are such as to make the removal of sheeting impracticable, that portion of the sheeting against which concrete has been placed may be left in place.

- 3) The reinforcing steel shall be set accurately and firmly in place.
- 4) The Contractor shall assume all risks of damage to the Work or to existing

improvements that may be attributable to this method of construction.

- 5) Should this method of construction prove unsatisfactory, the Contractor shall discontinue this method and construct the conduit by using outside forms.
- 6) No direct payment will be made for building paper, sheeting, guniting, for concrete placed outside of concrete lines shown on the Plans, or for cement used in such guniting and concrete. The cost thereof shall be included in the prices bid for the various items of work.

17-6.4 Removal of Forms

17-6.4.1 General — The periods of time for form removal set forth herein are permissive only and subject to the Contractor assuming all risks that may be involved. The time periods are minimum with no allowance therein for external loads. At times of low temperature, or other adverse conditions, the Engineer may require the forms to be kept in place for longer periods of time.

The time periods are predicated on the use of concrete to which no admixtures have been added for the purpose of obtaining a high early strength, and upon the use of the same type of cement throughout the structure. The Engineer may permit the use of admixtures, additional cement, or different types of cement in accordance with Subsection 17-1.2.4. If such permission is granted, the minimum time periods for stripping forms will be established by the Engineer in accordance with the materials, methods to be used, and the stresses to which the structure may be subjected.

When the Contractor elects to use Type IP (MS) cement in accordance with Subsection 17-1.2.1, minimum form removal times may be longer than indicated in the following subsections.

Forms and falsework supporting the bottom slab of the superstructure of box girder structures shall remain in place 14 days after placing the deck of the superstructure. Forms for the webs of box girders shall be removed before the deck slab is placed. Forms for the upper deck slab which are to remain in place shall be supported by bolts through the girder webs or some equally satisfactory method that will prevent the transfer of any load to the lower deck slab. Forms supporting the concrete deck slab of box girders may be left in place. All interior forms in box girders except those permitted to remain in place, shall be removed completely and the inside of the box girder cleaned of all loose material.

Side forms for beams, girders, columns, railings, or other members in which the forms do not resist dead load bending, may be removed within a period of 2 to 5 days, as authorized by the Engineer, provided that satisfactory

arrangements are made to cure and protect the concrete thus exposed.

Side forms for arch rings, columns, and piers shall be removed before the members of the structure which they support are cast so that the quality of the previously placed concrete may be inspected. Such forms shall be so constructed that they may be removed without disturbing other forms which support direct load or resist bending stress.

17-6.4.2 Miscellaneous Structures — The periods of time set forth herein are based on the use of Type II cement.

Forms for concrete members (except bridges) subject to bending stresses, where the member relies upon forms for vertical support, may be removed 7 days after concrete is placed.

Curb forms shall not be removed until the concrete has set sufficiently to hold its shape but shall be removed in time to permit proper finishing.

Stairway forms shall be removed and the finish of the steps completed on the day the concrete is placed. Metal stairway treads, if required by the drawings, shall be installed immediately after the steps have been poured.

17-6.4.3 Standard Structures

- a) General — Except as otherwise stipulated, the periods of time set forth herein for removal of forms are based on the use of Types II, III, IV, or V portland cement.
- b) Standard Catch Basins
 - 1) Outside forms and inside wall forms which do not support the top slab forms—16 hours.
 - 2) Top slab forms—48 hours if Type II or V cement is used; 24 hours if Type III cement is used.
- c) Standard Transition Structures
 - 1) Outside forms and inside wall forms which do not support the top slab form—16 hours.
 - 2) Top slab forms—as specified for box section slab forms.

17-6.4.4 Channels and Conduits

- a) General — Except as otherwise specified, the periods of time set forth herein are based on the use of Types II, III, IV or V portland cement.
- b) Forms Removal — Forms for open channels and forms and shoring for box sections and arch sections of sewers and storm drains may be removed as follows:
 - 1) Forms for open channel walls—16 hours.
 - 2) Outside forms of box sections and inside wall forms of box sections which do not support the slab forms—16 hours.
 - 3) Arch sections in open cut—12 hours.
 - 4) Slab forms for box sections—
 - (a) Type II cement—48 hours or 6 hours per foot (20 hours/m) of span between supports, whichever is greater.
 - (b) Type III cement—24 hours or 3 hours per foot (10 hours/m) of span between supports, whichever is greater.
 - (c) Type V cement—56 hours or 7 hours per foot (23 hours/m) of span between supports, whichever is greater.

17-6.5 Falsework

17-6.5.1 General — The Contractor shall submit detailed plans of the falsework proposed to be used. Such plans shall be in sufficient detail to indicate the general layout, sizes of members, anticipated stresses, grade of materials to be used in the falsework, and typical soil conditions.

Falsework may be bolted or spiked at the option of the Contractor, but the use of bolts and spikes shall not be combined in the same connection. The allowable spacings and connection values of bolts and spikes shall be in accordance with the National Design Specifications for Stress-Grade Lumber and its Fastenings as recommended by National Lumber Manufacturers Association, except that an additional allowance of 25 percent for temporary use shall be added to the connection values for bolts and spikes.

Ends of columns bearing on wedges shall be tied in both directions by girts.

17-6.6 Placing Reinforcement

17-6.6.1 General — Except for minor structures, driveways and sidewalk construction, the Contractor shall submit a reinforcing steel placing plan for approval.

Reinforcing bars shall be placed in accordance with the size and spacing shown on the plans. Reinforcing bars shall be firmly and securely held in position in accordance with the “*Manual of Standard Practice*” of the Concrete Reinforcing Steel Institute, using concrete or metal chairs, spacers, metal hangers, supporting wires and other approved devices of sufficient strength to resist crushing under full load. Metal chairs which extend to the surface of the concrete (except where shown on the Plans) and wooden supports, shall not be used. Tack welding on reinforcing bars will not be permitted.

Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted. Before placing in the form, all reinforcing steel shall be cleaned thoroughly of mortar, oil, dirt, loose mill scale, loose or thick rust, and coatings of any character that would destroy or reduce the bond. No concrete shall be deposited until the placing of the reinforcing steel has been inspected and approved.

Bar spacing is center to center of bars. Bar cover is clear distance between surface of bar and face of concrete and shall be 2 inches (50mm) unless otherwise noted on the Plans. Reinforcement shall terminate 2 inches (50mm) from concrete surfaces and expansion joints, unless otherwise noted on the Plans.

Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of prestressing products or tendons, as required to provide planned clearances to the prestressing tendons, anchorages, jacks and equipment, as approved by the Engineer.

17-6.6.2 Splicing — Splices of bars shall be made only where shown on the Plans or as approved by the Engineer. Where bars are spliced, they shall be lapped at least 30 diameters, unless otherwise shown on the Plans.

Splicing shall be accomplished by placing the bars in contact with each other and wiring them together.

Welding of reinforcing steel will not be permitted unless specifically authorized by the Engineer.

17-6.6.3 Bending Reinforcement — Bends and hooks in bars shall be made in the manner prescribed in the “*Manual of Standard Practice*” of the Concrete

Reinforcing Steel Institute.

Bars shall not be bent or straightened in a manner which will injure the material. Bars with kinds or unspecified bends shall not be used.

17-6.6.4 Welded Wire Fabric — Welded wire fabric shall be spliced not less than two meshes. It shall be lifted carefully into its specified position after the concrete is placed but still plastic.

17-6.7 Placing Concrete

17-6.7.1 General — Concrete shall be conveyed, deposited, and consolidated by any method which will preclude the segregation or loss of ingredients. Equipment used in conveying and depositing concrete shall not have any aluminum component in direct contact with the concrete.

All surfaces against which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete. All ponded and excess water shall be removed to leave surfaces moist but not flooded.

Chute used in conveying concrete shall be sloped to permit concrete of the consistency required to flow without segregation. Where necessary to prevent segregation, chutes shall be provided with baffle boards or a reversed section at the outlet.

Where a sequence for placing concrete is shown on the Plans, no deviation will be permitted unless approved in writing by the Engineer.

17-6.7.2 Grouting — Where concrete is to be deposited against hardened concrete at horizontal construction joints, placing operations shall begin by conveying a grout mixture through the placing system and equipment and depositing the mixture on the joint. The grout mixture shall consist of a modification of the concrete specified to reduce the quantity of coarse aggregate in the mix larger than pea-gravel size to one-half the quantity specified.

17-6.7.3 Depositing — To avoid segregation, concrete shall be deposited as near to its final position as is practicable. The use of vibrators for extensive shifting of the mass of concrete will not be permitted. Concrete that has partially hardened, has been retempered, or is contaminated by foreign materials shall not be deposited in the structure.

Concrete shall be placed in horizontal layers insofar as practical. Placing shall start at the low point and proceed up grade unless otherwise permitted by the Engineer. Concrete shall be placed in a continuous operation between

construction joints and shall be terminated with square ends and level tops unless otherwise shown on the Plans.

Concrete shall not be permitted to fall more than 6 feet (1.8m) without the use of pipes or tremies. Pipes and tremies shall be at least 6 inches (150mm) in diameter, or the equivalent cross-sectional area for rectangular sections. Concrete shall not be placed in horizontal members or sections until the concrete in the supporting vertical members of sections has been consolidated and a 2-hour period has elapsed to permit shrinkage to occur.

17-6.7.4 Consolidating — Concrete shall be thoroughly consolidated in a manner that will encase the reinforcement and inserts, fill the forms, and produce a surface of uniform texture free of rock pockets and excessive voids.

Structural concrete, except slope paving such as spillway aprons and channel lining, and concrete placed under water, shall be consolidated by means of high frequency internal vibrators of a type, size and number approved by the Engineer. The location, manner and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete without separation of the mortar and coarse aggregate, and without causing water or cement paste to flush to the surface. Internal vibrators shall not be held against the forms or reinforcing steel.

The number of vibrators employed shall be sufficient to consolidate the concrete within 15 minutes after it has been deposited in the forms. At least two vibrators in good operating condition shall be available at the site of the structure in which more than 25 cubic yards (19m³) of concrete is to be placed.

Approved external vibrators for consolidating concrete will be permitted when the concrete is not accessible to internal vibration. Forms and falsework shall be designed and constructed to resist displacement or damage from external vibration.

17-6.7.5 Walkways — Walkways and platforms shall be provided for personnel and equipment at a level convenient for the concrete placement and to permit the performance of all operations necessary for the completion of such work including finishing.

Where bridge decks are to be constructed to final roadway grade, walkways shall be provided outside the deck area along each side and for the full length of the structure. These walkways shall be of sufficient width and so constructed as to provide for the support of the bridges from which the longitudinal floats specified are to be operated.

17-6.7.6 Joints — The work shall be so prosecuted that construction joints will occur at designated places shown on the Plans unless otherwise authorized by the Engineer. The Contractor shall construct, in one continuous concrete placing operation, all work comprised between such joints. Joints shall be kept moist until adjacent concrete is placed.

All construction joints having a keyed, stepped, or roughened surface shall be cleaned by sandblasting prior to placement of the adjacent concrete, unless otherwise directed by the Engineer. Any quality of sand may be used which will accomplish the desired results.

The sandblasting operations shall be continued until all unsatisfactory concrete, laitance, coatings, stains, debris, and other foreign materials are removed. The surface of the concrete shall be washed thoroughly to remove all loose material. The method used in disposing of wastewater employed in washing the concrete surfaces shall be such that the wastewater will not stain, discolor, or affect exposed surfaces of the structures, and will be subject to the approval of the Engineer.

Expansion and contraction joints in concrete structures shall be formed where shown on the plans. No reinforcement shall be extended through the joints, except where specifically noted or detailed on the Plans.

No direct payment will be made for furnishing and placing asphalt paint, premolded asphalt filler, or other types of joint separators. The cost therefor shall be included in the price bid for the item of work of which they are a part.

17-6.7.7 Application of Joint Sealants

- a) General — All joint sealants shall conform to the general requirements for application and special requirements for each specific material shown below. Prior to sealing joints containing waterstops, the expansion joint filler, hardboard, concrete spillage, and all foreign material shall be removed from the deck joint down to a depth of the waterstops. All such material shall be removed from the entire depth of joints in curbs, sidewalks, railings, and the overhanging portion of deck slabs. Immediately before applying the joint sealant, the joint shall be thoroughly cleaned by abrasive blasting or other approved means to remove all mortar, laitance, scale, dirt, dust, oil, curing compounds and other foreign material. The joints shall be blown out with high pressure compressed air to remove all residue.

If sealant is shown in the sidewalk, saw-cutting of grooves at concrete railing locations shall be completed prior to constructing the railings. Joint

seal material shall be protected during the construction of the railing.

At the time of applying the joint sealant, the joint shall be surface dry, and acceptable to the Engineer. No sealant shall be placed during unsuitable weather or when the atmospheric temperature is below 50°F (10°C), or when weather conditions indicate that the temperature may fall below 32°F (0°C) within 24 hours.

The joint shall be filled from the bottom to the top without formation of voids. The top of the finished joint seal shall be between ¼ inch and ⅜ inch (6 and 10mm) below the finished surface.

All adjoining surfaces shall be carefully protected during the joint sealing operations, and any stains, marks or damage thereto, as a result of the Contractor's operations, shall be corrected in a manner satisfactory to the Engineer.

17-6.7.8 Placing Concrete Under Adverse Weather Conditions — Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the atmospheric temperature is below 35°F (2°C), unless adequate means are employed to heat the aggregates and water, and satisfactory provisions have been made for protecting the work.

Concrete slabs shall not be placed on frozen ground, nor shall concrete be mixed or placed when the atmospheric temperature is below 35°F (2°C), or when conditions indicate that the temperature may fall to 35°F (2°C) within 24 hours, except with the written permission of the Engineer and only after such precautionary measures for the protection of the pavement have been taken as the Engineer may direct.

Concrete shall be effectively protected from freezing or frost for a period of 5 days after placing.

Concrete for structures shall not be mixed or placed while the atmospheric temperature is above 115°F (46°C) unless adequate means are employed to cool the aggregate and water and satisfactory provisions have been made for protecting the work. In any case, the temperature of the concrete as placed shall not exceed 90°F (32°C).

Concrete placement shall be stopped when rainfall is sufficient to cause damage to the work.

17-6.8 Surface Finishes

(a) General — The classes of surface finish described herein shall be applied

to various parts of concrete structures as specific in the Special Provisions, and herein.

The invert of cast-in-place sewers and sewer structures shall be given a steel trowel finish. The invert in circular conduit is defined as the unlined portion of lined conduit or the bottom 60 degrees of circumference of the inside of unlined conduit. Unless otherwise specified, the invert of cast-in-place storm drains shall be given a wood-float finish.

(b) Ordinary Surface Finish — Immediately after the forms have been removed, all exterior form bolts shall be removed to a depth of at least 1 inch (25mm) inside the surface of the concrete and the resulting holes or depressions cleaned and filled with mortar, except on the interior surfaces of box girders the bolts may be removed flush with the surface of the concrete. Mortar shall be Class “C.” White cement shall be added to the mortar in an amount sufficient to tint the mortar a shade lighter than the concrete to be repaired. Mortar shall be mixed approximately 45 minutes in advance of use. Care shall be exercised to obtain a good bond with the concrete. After the mortar has thoroughly hardened, the surface shall be rubbed with a carborundum stone in order to obtain the same color in the mortar as in the surrounding concrete. All fins caused by form joints, and other projections shall be removed and all pockets cleaned and filled. Mortar for filling pockets shall be treated as specified for bolt holes.

Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher-class finish. On surfaces which are to be buried underground or surfaces which are completely enclosed (such as the cells of box girders), the removal of fins and form marks and the rubbing of a mortared surface to a uniform color will not be required. Ordinary surface finish, unless otherwise specified, shall be considered as a final finish on the following surfaces:

- 1) The undersurface of slab spans, box girders, filled-spandrel arch spans and floor slabs between T-girders of superstructures except for grade-separation structures.
- 2) The exposed surfaces of channel walls and the inside vertical surface of T-girders of superstructures except for grade-separation structures.
- 3) Surfaces which are to be buried underground, covered with fill, or for surfaces of culverts above finish grade which are not visible from the traveled way.
- 4) Top surfaces which are to be buried underground shall be struck off and given a float finish.

17-6.9 Curing — As soon after the completion of the specified finishing operations as the condition of the concrete will permit without danger of consequent damage thereto, all exposed surface shall either be sprinkled with water, covered with plastic sheet, or covered with earth, sand or burlap, or when not required to be painted, sprayed with Type 1 curing compound conforming with Subsection 17-4.1.

When an impervious membrane (curing compound) is used, it shall be applied under pressure through a spray nozzle in such manner and quantity as to entirely cover and seal all exposed surfaces of the concrete with a uniform film. The membrane shall not be applied to any surface until all of the finishing operations have been completed; such surface being kept damp, until the membrane is applied. All surfaces on which a bond is required, such as construction joint, shear planes, reinforcing steel, and the like, shall be adequately covered and protected before starting the application of the curing compound in order to prevent any of the compound from being deposited thereon; and any such surface with which the compound may have come in contact shall immediately thereafter be cleaned. Care shall be exercised to prevent any damage to the membrane seal during the curing period. Should the seal be damaged before the expiration of 10 days after the placing of the concrete, additional impervious membrane shall be immediately applied over the damaged area.

Should any forms be removed sooner than 10 days after the placing of the concrete, the surface so exposed shall either be immediately sprayed with a coating of the curing compound, or kept continuously wet by the use of burlap or other suitable means until such concrete has cured for at least 10 days.

When tops of walls are cured by the curing compound method, the side forms, except for metal forms, must be kept continuously wet for the 10 days following the placing of the concrete.

If there is any likelihood of the fresh concrete checking or cracking prior to the commencement of the curing operations (due to weather conditions, materials used, or for any other reason), it shall be kept damp, but not wet, by means of an indirect fine spray of water until it is not likely that checking or cracking will occur, or until the curing operations are started in the area affected.

17-6.10 Payment — Payment for concrete structures will be made in conformity with the terms of the Contract and will be based on unit prices or lump sums as set forth in the Bid. When payment is provided for on a lump sum basis, such payment shall include full compensation for furnishing all labor, materials, tools and equipment and doing all work required to construct the structure in conformity with the Plans and Specifications.

Where concrete is scheduled for payment on the basis of cubic yards (m³), the

calculation of the quantity of concrete for payment will be made only to the neat line of the structures as shown on the Plans and on the basis of the concrete having the specified dimensions. However, all concrete shall be placed to line and grade within such tolerances, as determined by the Engineer, are reasonable and acceptable for the type of work involved. The quantity of such concrete will be calculated considering the mortar used to cover construction joints as being concrete and no deductions will be made for rounded or beveled edges, space occupied by reinforcing steel, or metal inserts or openings 6 square feet (0.5m²) or less in area. The cost of cement used in mortar for covering construction joints, patching, or other uses in the structure being constructed, in excess of that required for the design mix of the adjacent concrete, shall be included in the item of work of which said mortar is a part.

The quantity of reinforcing steel, when scheduled as a separate item, will be calculated for payment on the basis of the number of each type bar actually placed in accordance with the Plans and approved changes. The weight will be calculated using the actual lengths of bars placed and the unit weights per linear foot (m) specified in ASTM A 615, A 616, and A 617.

Steel for laps indicated on the Plans, or required by the Engineer, will be paid for at the Contract Unit Price. No payment will be made for reinforcing steel in laps (whether specified or optional) which are not used, and payment will not be made for additional steel in laps which are requested by the Contractor for its convenience, or for steel used in chairs or other devices for supporting the required reinforcement. The cost of tie wire shall be included in the unit price bid.

Payment for longitudinal steel reinforcement will be made on the basis that the longest standard mill lengths will be placed; and not more than one lap will be paid for between two consecutive construction joints, unless otherwise authorized by the Engineer. The standard mill length for bar sizes No. 4 and larger is specified as 60 feet (18m).

when optional longitudinal construction joints are indicated on the Plans or specified, the Contractor will be permitted to lap the transverse reinforcing steel at said joints and the reinforcing steel used in such laps will be paid for at the Contract Unit Price.

17-7 Concrete Curbs, Walks, Gutters, Cross Gutters, Access Ramps and Driveways

17-7.1 General — Concrete curbs, walks, gutters, cross gutters, access ramps and driveways shall be constructed of portland cement concrete of the class and other requirements prescribed in Subsection 17-1.1.2. The finish coat to be applied to

curbs shall consist of Class "B" mortar prepared as prescribed in Subsection 17-5.

Unless otherwise specified on the Plans, the minimum thickness of walks shall be 4 inches. The minimum thickness of gutters, cross gutters, alley intersections, access ramps and driveway aprons shall be 6 inches (150mm).

17-7.2 Drainage Outlets Through Curb — Where existing building drains occur along the line of work, the new curb shall be suitably sleeved to provide for such drains. Similar sleeves shall be installed to serve low areas on adjacent property where drainage has been affected by the work.

The location and size of the sleeves and construction of connecting sidewalk drains shall be in accordance with the Plans.

17-7.3 Driveway Entrances — Driveway entrances shall be provided in new curb at all existing driveways along the line of the work, at locations shown on the plans, and at such other locations as may be designated by the Engineer.

The fully depressed curb opening at driveway entrances shall be 1 inch (25mm) above gutter flowline at the curb face. The top of the fully depressed portion of the curb shall be finished to a transverse slope toward the gutter of $\frac{3}{4}$ inch (20mm).

Where walk is to be constructed across driveways to commercial establishments, the thickness thereof shall be 6 inches (150mm) unless otherwise specified or indicated on the plans. At residential driveways, the thickness of the walk will be 6 inches (150mm) unless otherwise specified.

17-7.4 Forms — Form material shall be free from warp, with smooth and straight upper edges, and if used for the face of curb, shall be surfaced on the side against which the concrete is to be placed. Wooden forms for straight work shall have a net thickness of at least $1\frac{1}{2}$ inches (40mm). Metal forms for such a work shall be of a gage that will provide equivalent rigidity and strength. Curb face forms used on monolithic curb and gutter construction shall be of a single plank width when the curb face is 10 inches (250mm) or less, except for those used on curb returns. All forms used on curb returns shall be not less than $\frac{3}{4}$ inch (20mm) in thickness, cut in the length and radius as shown on the plans, and held rigidly in place by the use of metal stakes and clamps. The curb face form shall be cut to conform exactly with the curb face batter as well as being cut to the required length and radius. Forms shall be of sufficient rigidity and strength, and shall be so supported, as to adequately resist springing or deflection from placing and tamping the concrete.

Form material shall be clean at the time it is used; and shall be given a coating of light oil, or other equally suitable material, immediately prior to the placing of

the concrete.

All forms except back planks of curb shall be set with the upper edges flush with the specified grade of the finished surface of the improvement to be constructed, and all forms shall be not less than a depth equivalent to the full specified thickness of the concrete to be placed.

Back forms shall be held securely in place by means of stakes driven in pairs at intervals not to exceed 4 feet (1.2m), one at the front form and one at the back. Clamps, spreaders, and braces shall be used to such extent as may be necessary to ensure proper form rigidity. Forms for walk, gutter, and similar work shall be firmly secured by means of stakes driven flush with the upper edge of the form at intervals not to exceed 5 feet (1.5m). Form stakes shall be of sufficient size and be driven so as to adequately resist lateral displacement.

Commercial form clamps for the curb and gutter may be used provided they fulfill the requirements specified herein.

17-7.5 Placing Concrete — Concrete shall be placed on a subgrade sufficiently dampened to ensure that no moisture will be absorbed from the fresh concrete.

Concrete shall be placed in curb, gutter, and curb and gutter forms in horizontal layers not exceeding 6 inches (150mm) in thickness, each layer being spaded along the forms and thoroughly tamped. Concrete may be placed in layers of more than 6 inches (150mm) in thickness only when authorized by the Engineer and the spading and tamping is sufficient to consolidate the concrete for its entire depth.

After the concrete for walk has been placed, a strikeoff shall be used to bring the surface to the proper elevation when compacted. It shall be spaded along the form faces and tamped to assure a dense and compact mass, and to force the larger aggregate down while bringing to the surface not less than $\frac{3}{8}$ inch (10mm) of the free mortar for finishing purposes.

Concrete shall be placed in cross gutters in horizontal layers of not more than 4 inches (100mm) in thickness, each layer being spaded along the form faces and thoroughly tamped into a dense and compact mass. If internal vibrators are used, the full specified thickness may be placed in one operation.

After the concrete has been placed and tamped, the upper surface shall be struck off to the specified grade.

17-7.6 Joints

(a) **General** — Joints in concrete curb, gutter, and walk shall be designated as expansion joints and weakened plane joints. When replacing sidewalk

adjacent to existing sidewalk with varying joints and score lines, new joints and score line shall be placed to provide a reasonable resemblance to the existing patterns. A weakened plane joint shall be placed at all locations where utility boxes and other similar structures are located.

(b) Expansion Joints — Expansion and weakened plane joints shall be constructed in curb, walk and gutter as shown on the Plans or as specified herein. No such joints shall be constructed in cross gutters, alley intersections, access ramps or driveways except as may be approved by the Engineer.

One-quarter-inch (6mm) joints shall be constructed in curb and gutter at the end of all returns except where cross gutter transitions extend beyond the curb return, in which case they shall be placed at the ends of the cross gutter transition. No joints shall be constructed in returns. Where monolithic curb and gutter is constructed adjacent to concrete pavement, no expansion joints will be required except at EC and BC of curb returns.

One-quarter-inch (6mm) joints shall be constructed in walk returns between the walk and the back of curb returns when required by the Engineer. At the EC and BC and around utility poles, the joint filler-strips shall extend the full depth of the concrete being placed. Joint filler-strips between walk and curb shall be the depth of the walk plus 1 inch (25mm) with the top set flush with the specified grade of the top of curb.

All expansion joint filler strips shall be installed vertically, and shall extend to the full depth and width of the work in which they are installed, and be constructed perpendicular to straight curb or radially to the line of the curb constructed on a curve. Expansion joint filler materials shall completely fill the joints to within $\frac{1}{4}$ inch (6mm) of any surface of the concrete. Excess filler material shall be trimmed off to the specified dimension in a neat and workmanlike manner. During the placing and tamping of the concrete, the filler strip shall be held rigidly and securely in proper position.

(c) Weakened Plane Joints

(1) General — Weakened plane joints shall be straight and constructed in accordance with Subsections (2) or (3) below, unless otherwise shown on the Plans.

In walk, joints shall be transverse to the line of work and at regular intervals not exceeding 10 feet (3m). At curves and walk returns, the joints shall be radial.

In gutter, including gutter integral with curb, joints shall be at regular intervals not exceeding 20 feet (6m). Where integral curb and gutter is

adjacent to concrete pavement, the joints shall be aligned with the pavement joints where practical.

(2) Control Joint — After preliminary trowelling, the concrete shall be parted to a depth of 2 inches (50mm) with a straightedge to create a division in the coarse aggregate. The concrete shall then be refloated to fill the parted joint with mortar. Headers shall be marked to locate the weakened plane for final joint finishing, which shall be accomplished with a jointer tool having a depth of $\frac{1}{2}$ inch (13mm) and a radius of $\frac{1}{8}$ inch (3mm). The finished joint opening shall not be wider than $\frac{1}{8}$ inch (3mm).

(3) Plastic Control Joint (Score Line) — The joint material shall be a T-shaped plastic strip at least 1-inch (25mm) deep, having suitable anchorage to prevent vertical movement, and having a removable stiffener with a width of at least $\frac{3}{4}$ inch (20mm). After preliminary trowelling, the concrete shall be parted to a depth of 2 inches (50mm) with a straightedge. The plastic strip shall be inserted in the impression so that the upper surface of the removable stiffener is flush with the concrete. After floating the concrete to fill all adjacent voids, the removable stiffener shall be stripped. During final trowelling, the edges shall be finished to a radius of $\frac{1}{8}$ inch (3mm), using a slit jointer tool.

17-7.7 Finishing

(a) General — Finishing shall be completed as specified herein for the type work being performed.

(b) Curb — The front forms may be stripped as soon as the concrete has set sufficient. Class "B" mortar, as prescribed in Subsection 17-5 and thinned to the consistency of grout, shall be immediately applied to the top and face of the curb if needed. If monolithic curb and gutter is being constructed, this mortar shall be applied to the full exposed curb face; otherwise, it shall extend 2 inches (50mm) below the gutter surface.

The face and top of the curb shall then be carefully trowelled to a smooth and even finish; the top being finished to a transverse slope of $\frac{1}{4}$ inch (6mm) toward the gutter, with both edges rounded to a radius of $\frac{1}{2}$ inch (13mm). The trowelled surface shall be finished with a fine-hair broom applied parallel with the line of the work. The edge of the concrete at all expansion joints shall be rounded to a $\frac{1}{4}$ -inch (6mm) radius. The surface of the work shall be finished as prescribed; after which the name of the Contractor, together with the year in which the improvement is constructed, shall be stamped therein to a depth of $\frac{1}{4}$ inch (6mm) in letters not less than $\frac{3}{4}$ inch (20mm) high, at BC and EC of curb returns.

Joints shall conform to Subsection 17-7.6.

(c) Walk — The forms shall be set to place the finished surface in a plane sloping up from the top of curb 2 percent when measured at right angles to the curb.

Following placing, the concrete shall be screened to the required grade, tamped to consolidate the concrete and to bring a thin layer of mortar to the surface, and floated to a smooth, flat uniform surface. The concrete shall then be edged at all headers, given a preliminary trowelling and provided with weakened plane joints.

Walk shall be steel trowelled to a smooth and even finish. All formed edges shall be rounded to a radius of ½ inch (13mm). Edges at expansion joints shall be rounded to a radius of ⅛ inch (3mm). Preliminary trowelling may be done with a longhandled trowel or “Fresno,” but the finish trowelling shall be done with a hand trowel. After final trowelling, walk on grades of less than 6 percent shall be given a fine hair-broom finish applied transverse to the center line. On grades exceeding 6 percent, walk shall be finished by hand with a wood float. Walk shall be remarked as necessary after final finish, to assure neat uniform edges, joints, and score lines.

Scoring lines, where required, shall have a minimum depth of ¼ inch (6mm) and a radius of ⅛ inch (3mm). When longitudinal scoring lines are required, they shall be parallel to, or concentric with, the lines of the work. Walk 20 feet (6m) or more in width shall have a longitudinal center scoring line. In walk returns, one scoring line shall be made radially midway between the BCR and ECR. When directed by the Engineer, longitudinal and transverse scoring lines shall match the adjacent walk. The Contractor shall have sufficient metal bards, straightedges, and joint tools on the project.

Headers shall remain in place for at least 16 hours after completion of the walk but must be removed before the Work is accepted.

(d) Gutter — After the concrete has been thoroughly tamped in such manner as to force the larger aggregate into the concrete and bring to the top sufficient free mortar for finishing the surface shall be worked to a true and even grade by means of a float, trowelled with a long-handled trowel or “Fresno” and wood float-finished. The flowline of the gutter shall be trowelled smooth for a width of approximately 4 inches (100mm) for integral curb and gutter and 4 inches (100mm) on either side of the flowline on cross gutters and longitudinal gutters. The outer edges of the gutter shall be rounded to a radius of ½ inch (3mm).

Side forms shall remain in place for at least 24 hours after completion of the

gutter, but must be removed before the work will be accepted.

Joints shall conform to Subsection 17-7.6.

(e) Access Ramps and Driveways — Alley intersections, access ramps and driveways shall be constructed as specified for concrete pavement in Subsection 17-7.5 except final finishing for access ramps and the sloping portion of driveways shall be done by hand with a wood float and the remaining portion of the driveway finished as specified for walks in accordance with Subsection 17-7.7(c).

17-7.8 Curing — Immediately after finishing operations are completed, Type 1 concrete-curing compound shall be applied.

The curing compound shall be applied under pressure, by means of a spray nozzle, in such manner and quantity as to entirely cover all exposed surfaces of the concrete with a uniform film. Curing compounds shall be as specified in Subsection 17-4.

No power equipment used for the preparation of subgrade will be permitted adjacent to concrete curb, gutter, or alley intersections until the fourth day following placement of the concrete. The placement of bituminous pavement adjacent to concrete curb, gutter, or alley intersections will not be permitted until the seventh day following the placement of concrete nor will concrete paving operations be permitted until the seventh day where placing or finishing equipment will ride on the previously placed concrete. If admixtures, additional cement or Type III cement is used to obtain high early strength concrete in accordance with Subsection 17-1.1.1, grading operations will be permitted on the second day following the placement of the concrete and paving operations on the third day.

17-7.9 Repairs and Replacements — Any new work found to be defective or damaged prior to its acceptance shall be repaired or replaced by the Contractor at no expense to the Agency.

17-7.10 Backfilling and Cleanup — Backfilling to the finished surface of the newly constructed improvement must be completed before acceptance of the Work.

Upon completion of the work the surface of the concrete shall be thoroughly cleaned and the site left in a neat and orderly condition.

17-7.11 Measurement and Payment — Payment for concrete curbs, walks, gutters, cross gutters, access ramps and driveways will be made as shown in the Bid.

Measurements to determine the pay quantities will be made in horizontal planes,

including but not limited to removal of existing concrete, disposal, subgrade preparation backfilling and cleanup.

The price bid shall be considered to include full payment for all materials, labor, equipment and incidentals require to construct the concrete improvements in accordance with the plans and Specifications.